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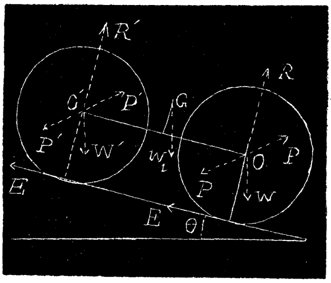
The forces on car and rear wheels are, this force P at O, w_1 at G, w at O', R_1 the reaction of the plane, and F the force of friction.

From forces on front trucks we have,

$$\left.\begin{array}{l}(1).\ w\sin\theta=P\cos\psi \\ (2).\ w\cos\theta=R-P\sin\psi\end{array}\right\}\psi \text{ being the angle between } P \text{ and the line of centers } OO'.$$

From forces on car and rear wheels, letting μ be coefficient of friction, taking moments about O' and resolving horizontally and vertically,



(3). $2aP\sin\psi=w_1(a+b\tan\theta)\cos\theta-\mu R_1c$.

(4). $\mu R_1=(w+w_1)\sin\theta+P\cos\psi$.

(5). $R_1+P\sin\psi=(w+w_1)\cos\theta$.

From these five equations we get,

$$\tan\theta=\frac{a\mu(2w+w_1)}{aw_1b+(2a-c\mu)(2w+w_1)}\ldots\ldots(A).$$

Next take the case when brakes are applied to front wheels, considering in this case, the rear trucks as one rigid body, and the car with front trucks as the other. The two oblique forces P now act at O' one upon the car and one upon rear wheels (lettered P' to avoid confusion).

From forces on rear wheels we get,

$$\left.\begin{array}{l}(a).\ w\sin\theta=P'\cos\psi' \\ (b).\ w\cos\theta=R_1-P'\sin\psi'\end{array}\right\}\psi' \text{ being the angle between } P' \text{ and } OO'.$$

From forces on car and front wheels, taking moments about O, resolving horizontally and vertically.

(c). $2aP'\sin\psi'=w_1(a-b\tan\theta)\cos\theta-\mu Rc$.

(d). $\mu R=(w+w_1)\sin\theta+P'\cos\psi'$.

(e). $R+P'\sin\psi'=(w+w_1)\cos\theta$.

From these five equations we get

$$\tan\theta=\frac{a\mu(2w+w_1)}{(2a-\mu c)(2w+w_1)-\mu w_1b}\ldots\ldots(B).$$

Comparing (B) with (A) we see that in the latter case $\tan\theta$, and hence θ, is the greater, and hence we infer it is more advantageous to apply the brakes to the front wheels.

80. Proposed by B. F. FINKEL, A. M., M.Sc., Professor of Mathematics and Physics, Drury College, Springfield, Mo.

A circular board is placed on a smooth horizontal plane and a boy runs with uniform speed around on the board close to the edge. Find the motion of the center of the board.

I. **Solution by GEORGE R. DEAN, Professor of Mathematics, University of Missouri School of Mines and Metallurgy, Rolla, Mo.**

The system is not acted upon by any external force. Hence the center of gravity is stationary. Let I be the moment of inertia of the board about its center, m the mass of the board, m' that of the boy, r the distance of center of system from center of board, ω the angular velocity of board. Then $I\omega^2+mr^2\omega^2=m'v^2$.

II. **Solution by G. B. M. ZERR, A. M., Ph. D., Professor of Mathematics and Science, Chester High School, Chester, Pa.**

Let $AC=a$ be the radius of board, A the starting point of the boy, m his mass, P the mass of the board, G the center of gravity of the system at starting.

Since there are no horizontal forces *external* to the system, by D'Alembert's principle, the center of gravity of the system must move downwards; but this is impossible.

$\therefore$ The equation of motion of the center of gravity is, $m\dfrac{d^2\bar{x}}{dt^2}=0$.

$\therefore \dfrac{d\bar{x}}{dt}=0$, since both boy and board start from rest.

$\therefore \bar{x}=$a constant. $\therefore$ The center of gravity of the system remains unaltered throughout the motion.

Hence since the distance between the center of the board and boy remain constant, the distances of the center of gravity from the boy and the center of the board respectively will remain constant.

$\therefore$ C describes a circle with $GC=\dfrac{ma}{m+P}$ as radius.

$\therefore$ A describes a circle with $AG=\dfrac{Pa}{m+P}$ as radius.

$\therefore$ both center of board and boy describe circles. If $m=P$ these circles will be equal and have AC for diameter.

MISCELLANEOUS.

69. **Proposed by WILLIAM SYMMONDS, A. M., Professor of Mathematics and Astronomy, Pacific College, Santa Rosa, P. O., Sebastopol, Cal.**

Find the locus of a point equi-distant from the circumferences of two fixed circles.

I. **Solution by H. C. WHITAKER, A. M., Ph. D., Professor of Mathematics, Manual Training School, Philadelphia, Pa.**

Denote the two given circumferences by K_1 and K_2; take their centers at $(-\tfrac{1}{2}a, 0)$ and $(\tfrac{1}{2}a, 0)$; denote their radii by r_1 and r_2, r_1 not being less than r_2. Let (x, y) denote a point in the desired locus.

Then if (x, y) is inside K_1 and inside K_2,

$$r_1-\sqrt{[(x+\tfrac{1}{2}a)^2+y^2]}-\{r_2-\sqrt{[(x-\tfrac{1}{2}a)^2+y^2]}\}=0\ldots\ldots(1).$$